Letters to the Editor.

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The Aurora of May 13–15.

In pursuance of the programme outlined in my letter to Nature of March 31, p. 137, I have been photographing the spectrum of the night sky every night. On the night of May 13–14, and also of May 14–15, a strong auroral spectrum was obtained, showing the aurora line λ5578, and also the negative bands of nitrogen, which were much stronger than the aurora line. Ten heads of these bands were shown on the photograph of May 14–15, though only six appear within the same spectral range in Vegard's investigation made on a special expedition to the Arctic.

That these nitrogen bands should be actually stronger than the aurora line is very remarkable. On ordinary nights it is generally possible to photograph the aurora line, while the nitrogen bands have never been photographed in the course of about 100 nights except on these two consecutive occasions.

It is of interest to note that the aurora apparently ceased before the magnetic storm was over, according to the data given by Dr. Chree in Nature of May 19, p. 359. On the night of May 15–16 the aurora line was barely, if at all, visible on the plate, and below its average intensity on ordinary nights. Nothing could be seen of the nitrogen bands.

Rayleigh.

The Gravitational Field of an Electron.

In the Proceedings of the Royal Society for February last (vol. xcix., A, p. 123) is an interesting paper by Dr. G. B. Jeffery, in which he applies an extension of Einstein's theory to ascertain something about the state of the æther close to an electron—though perhaps he might not express it in that way. He obtains independently, and then discusses, a result recently published by Nordström, namely, an extension of the now well-known γ of Schwarzschild's equation,

$$ds^2 = \gamma^{-1}dr^2 + \text{etc.} - \gamma c^2 dt^2,$$

by adding to it a mixed gravitational and electrical term, so that it becomes

$$\gamma = 1 - \frac{2Gm}{rc^2} + \frac{Ge^2}{Kr^2c^4};$$

wherein, while the old second term involves the gravitational potential, the new third term involves the square of the electrostatic potential.

I have introduced the dielectric constant of the æther into the denominator so as to keep dimensions right, and if we now choose to make use of the familiar "J. J. T." (1881) expression for the inertia of an electric charge, $m = 2\mu e^2/3a$—which is reasonable, inasmuch as the gravitation constant is dominant over both the second and third terms—we may write the above value of γ thus:

$$\gamma = 1 - \frac{2Gm}{rc^2}\left(1 - \frac{3}{4}\frac{a}{r}\right).$$

This expression attains a minimum value when $r = \frac{3}{2}a$; and it is unity both at infinity and at $r = \frac{3}{4}a$. This last probably means that the electric and mass terms just balance at the surface of an electron (for we may probably ignore the $\frac{3}{4}$ factor as unlikely to be accurate so close to a charge), or else it means that the gravitational effect at an electron-boundary is reduced to one-quarter of its normal value. The formula does not apply in the interior of an electron, if an electron has any interior; though if it is a geometrical point, as Dr. Jeffery evidently thinks possible, then γ may rise to a very high value within what is commonly thought of as the boundary.

It is not to be thought that the new term is merely the natural consequence of electromagnetic mass, for it is opposed in sign; the electrical and the mass effects tend to neutralise each other; but nowhere do they succeed except at or near the boundary of an electron. For all distances large compared with the size of an electron γ has its customary Einstein value, so the third term has no astronomical significance whatever.

But a study of what happens to radiation when it impinges on, or penetrates between, the ultimate elements of matter—in fact, a study of the whole behaviour of a stream of radiation at its two ends, the source and the sink—is obviously of great importance. An immense amount of work has been done on the emission end of radiation, but less on the absorption end. By the two together we may ultimately hope to get some information as to the structure of an electron. It may be pardonable to mention some small papers of my own in this connection, in the *Philosophical Magazine* for April and probably for June and July this year, though the full working out is not attempted.

It must be emphasised that the e^2, above, means the square of the unbalanced charge only—it is $(\Sigma e)^2$ not $\Sigma(e^2)$—and that all neutralised charges are provided for by the second term. The conclusion that unbalanced electric potential and neutralised or mass potential oppose each other in their warping effect on the æther appears rather suggestive. I confess I should have expected a third term which did not involve the gravitation constant; and perhaps there may be a reconsideration on this point, for the present manner of obtaining the expression is far from easy—in fact, is abstruse.

Oliver Lodge.

The Magnetic Storm of May 13–17.

The magnetic storm which began soon after 1 p.m. on May 13 presented several unusual features beyond that of almost unprecedented magnitude. As recorded on the Eskdalemuir magnetographs, it showed a "sudden commencement" at 13h. 1½m. G.M.T. on May 13. The phenomenon known by this name usually takes the form of a sharp change in value of the horizontal components of terrestrial force, frequently including as its first part a temporary drop in value lasting for about a minute, but always exhibiting a rise in value immediately thereafter. In the vertical component the change, when appreciable, is very much slower and is in the direction of the zenith. In the case of the storm now described the change in the north component was too quick for the photographic paper to receive a visible impression of the light spot. On the west component a drop in value is shown at first, amounting to 29γ (0·00029 C.G.S.) and extending over two minutes. There then followed a rise of 94γ, occupying 2½ minutes. On the vertical component the "sudden commencement" assumed an unusual form. There is quite clear evidence of a preliminary increase in value of the vertically downward directed force amounting to 8γ, followed immediately by a reverse change of 31γ, the latter being much more rapid than is generally the case. These preliminary phases having passed, the main features of the disturbance were quickly developed. This is quite in accord with the results of

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previous experience, which shows that, as a rule, when a "sudden commencement" occurs not far from noon of local time the principal maxima and minima of the storm occur within the next twelve or fifteen hours, but that if the "sudden commencement" occurs late in the day the full development of the disturbance is postponed until the *post-meridiem* hours of the following day.

The changes in the horizontal components of force throughout the disturbance were on a very large scale, and took place with a rapidity so great that the photographic traces are in some parts too faint to read. But the most unusual feature of the storm was the remarkable series of changes in the value of the vertical component of force. In most magnetic storms the general course of events comprises (1) a gradual increase in V to a maximum (in some cases two successive maxima) reached about 18h. local time, (2) a gradual fall until midnight, (3) a rapid fall to a minimum which is reached about 1h., (4) a gradual recovery to nearly the undisturbed value, which recovery is completed by about 8h., and is sometimes accompanied by (5) a series of short-period pulsations. The whole sequence is frequently repeated on a modified scale later on in the second day. In the storms now described this course of events was followed so far as the first twenty-four hours are concerned. The first maximum on May 13 was reached at 20h. 37m., and was 152γ above the undisturbed value at the time of the "sudden commencement." One or two falls in value succeeded until 21h. 24m., when a rapid fall of more than 350γ in six minutes carried the light spot off the paper. The principal minimum which then occurred took place at an unusually early hour (see "British Meteorological and Magnetic Yearbook," 1915, part iv., p. 89, and plate vi.). According to the theory which would account for magnetic storm phenomena by assigning them to the earth's rotation in a beam of particles emanating from the sun, this sudden drop in the value of V might be supposed to take place at or soon after midnight of local time, but not so early as 9 p.m. The rate of change in V during the descent to the minimum referred to was large, but by no means the largest recorded at Eskdalemuir. For example, the storm of March 23, 1920, showed a case of V changing at the rate of 169γ per minute. The gradual recovery which followed the minimum was accompanied, particularly between 6h. and 8h., by pulsations of about four minutes' period and of amplitude averaging about 4γ. It is, perhaps, unsafe to generalise, but there is some evidence to show that such pulsations in vertical force do not occur in a magnetic storm unless the total range of disturbance in V exceeds a certain amount.

The second twenty-four hours of the storm showed even more remarkable developments than the first. After several maxima and minima had been passed the value of V began to fall about 23h. on May 14, and the light spot went off the paper at midnight. Between 1h. and 6h. on May 15 at least a dozen extensive and rapid changes in V took place, swinging the light spot alternately beyond the upper and below the lower edge of the paper. The most clearly marked of these occurred between 2h. 40m. and 2h. 44m. on May 15, and involved a change during that interval at the rate of 138γ per minute. Repeated oscillations of this character and magnitude have not hitherto been recorded at Eskdalemuir. The course of the disturbance during May 16 was remarkable in that the fall in the value of V during the early hours of the morning continued until nearly 7h.

The storm had practically died down by noon on May 17, but soon after 23h. on that day another "sudden commencement" was recorded, and the sheet which will be taken off the recording drums to-morrow morning will probably show a recurrence of disturbance.

A. CRICHTON MITCHELL.

Eskdalemuir Observatory, May 18.

Ocean Tides.

THE article in NATURE of March 10, p 33, on oceanographic problems by "J. J." prompts one interested in tides to direct attention to the services which a new *Challenger* expedition might render to the general theory of ocean tides at relatively little cost either in time or in money.

There are numerous localities for which tidal information is either inadequate or wholly lacking. Sir George Darwin directed attention to some of these places by publishing in the *Geographical Journal* of November, 1909, a memorandum prepared by the late Dr. R. A. Harris, of the U.S. Coast and Geodetic Survey. The "dozen or so landing parties placed here and there over the world" suggested by "J. J." could undoubtedly use to advantage as their bases of operations some of these places for which tidal observations are needed. These suggested landing parties could therefore, in connection with their other observations, secure tidal data of great value.

It may not, perhaps, be amiss here to point out that such tidal observations would serve two important purposes. In the first place, they would increase our geographical knowledge of the regional distribution and local characteristics of the tides; and in the second, they would furnish further data of an accurate character to test the merits of the various tidal theories that attempt to interpret mathematically the terrestrial phenomena of the tides. Thus some of the places for which tidal information is desired are of critical importance to the so-called "stationary wave" theory of tides, which appears steadily to be gaining in favour.

The use of automatic or self-recording tide gauges would, of course, be most desirable. In this connection it is to be noted that such tide gauges may now be had in small and inexpensive types that require no elaborate installation and may be expeditiously set up. It cannot, however, be too strongly emphasised that valuable additions to our knowledge of the tides at out-of-the-way or infrequently visited places may be secured by recording hourly the height of the tide as registered on a naked tide-staff graduated to feet and tenths. The longer the series of observations, the better; but even a day or two will furnish considerable information.

The value of the tidal observations would be greatly enhanced if bench-marks of a permanent character were established and the relation of the zero of the tide-staff to these bench-marks determined. This would make possible correlation with any future tidal observations at the same places, and might even permit a quantitative determination of the local rate of elevation or subsidence of the land relative to the sea.

A fertile and almost virgin field is offered to the investigators of a new *Challenger* expedition in the study of the tides of the open sea, the importance of which is obvious. Several forms of automatic tide gauges adapted for offshore tidal observations appear to have given satisfactory service. Recently an offshore hydrographic party secured an excellent series of tidal observations by means of an improvised tide gauge consisting of a graduated tide-staff secured to a float and confined in a float-tube made up of sections of 2-in. pipe, the lowest section of which was cast into a block of cement. It also appears that satis-

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